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ON THE PRODUCTION OF SANITARY MILK.*

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THE experiments reported in this paper were undertaken with a view to arriving at definite conclusions in reference to some stages in the production of sanitary milk, or so-called "certified milk." The results shall be discussed under four heads, with an added fifth part for a short criticism of dairy score cards. The four experimental parts are:

1. A study of the bacterial content of separator milk and cream.
2. Comparative tests of the value of narrow top pails with and without strainers.
3. A study of the action of absorbent cotton strainers on the bacterial content of milk.
4. An attempt at classification of body cells in the slime of the separator.

The experiments were carried on during the month of September, 1909, at a model dairy in Wisconsin.[1] All conditions and precautions for the production of sanitary milk are carried out here to the smallest detail. All utensils are thoroughly sterilized, the separator in the bottling-room is sterilized with live steam before use, the bottling-room is finished with glazed tile in such fashion as to offer smooth surfaces for the play of steam, and the cows are in perfect health. We were thus enabled to obtain samples and carry on the work with the assurance that the possibilities for contamination were minimized and that the milk was the natural product of healthy cows.

Methods.—The samples were taken with sterile pipettes from the milk after thorough mixing, excepting the samples from the separator milk and cream, which were taken while the milk and cream were flowing from the separator. The contents of the pipettes were discharged into tubes containing 9 c.c. sterile water. One c.c. of this dilution was mixt in a petri dish with the contents of a tube of liquefied beef-extract agar, containing 1 per cent glucose and having a reaction of 1 per cent acid. The

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[1] We are greatly indebted to the owners and the manager, Mr. A. J. Obenberger, of the Edgewood Farms at Pewaukee, Wis., for putting material, apparatus, and space at our disposal, and for the courtesy and hospitality shown us during the progress of the work.

plates were kept in a dark box at room temperature. Frequent observations of the temperature showed that it varied but little, averaging about 18° C. The colonies were counted after three days with a lens magnifying about five times. The samples for the experiments under 2 and 3 were taken from the morning's milking at 5 A. M. and all plating was finished at about 7 A. M. or a little later. The samples for experiments 1 and 4 were taken from the separator milk and cream at about 4 P. M. and also plated immediately. It is the usual experience in sanitary dairies that the morning milk contains somewhat higher numbers of bacteria than the afternoon milk, this probably being due to the fact that the general condition of the stables, after the cows have passed the night indoors, is not as good as it is after the stables and cows have been thoroughly cleaned.

A STUDY OF THE BACTERIAL CONTENT OF SEPARATOR MILK AND CREAM.

This subject has received the attention of some investigators, but the opinions of these are at variance with each other. Wyss[1] thought that a large number of bacteria were thrown out into the separator slime. He also stated that the milk is purified by the process of separation. Scheurlen[2] claimed that the centrifugal cream as well as gravity cream contains more bacteria than the milk before centrifugation. He worked with 20 per cent cream. Niederstadt[3] came to the conclusion that the cream contains 75 per cent of all bacteria originally found in the milk and the separator milk only 25 per cent. Rolet[4] found, after centrifuging five samples of milk, that on the average the cream contained slightly more bacteria than the milk. Russell[5] states that gravity cream is usually richer in bacteria than separator cream, but that this is mainly due to the age of gravity cream. Both kinds of cream according to this author contain more bacteria than the milk from which they are obtained. He also states[6] that separator cream usually contains larger numbers of bacteria than the separator milk. Russell and Hastings[7] make substantially the same statements. Anderson[8] also found that both gravity and separator cream contain more bacteria than the milk. Wilkens[9] on the other hand stated that centrifugalized milk contains less bacteria than the original milk, but agrees with the other authors cited, that the majority of bacteria go into the cream. He ascribed the reduction of bacteria to the violent rotation of the centrifuge, in consequence of which, he thought, many bacteria are killed.

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[1] *Centralbl. f. Bakt.*, 1889, 6, p. 587.

[2] *Arbeit. a. d. kais. Ges.*, 1891, 7, p. 269.

[3] *Koch's Jahresber.*, 1893, 4, p. 205.

[4] *Ibid.*, 1901, 12, p. 340.

[5] *Outlines of Dairy Bacteriology*, 1894, pp. 126, 127.

[6] *Ibid.*, p. 125.

[7] *Experimental Dairy Bacteriology*, 1909, p. 93.

[8] *Jour. Infect. Dis.*, 1909, 6, p. 392.

[9] *Centralbl. f. Bakt.*, Ref., 1894, 16, p. 969.

Wholly different results were obtained by Backhaus and Cronheim.[1] These authors found that the total number was actually decreased by centrifugation, but that the majority of bacteria go into the skim milk. They also showed that 95.6 per cent of the dirt in the milk was thrown out by the separator. Swithinbank and Newman[2] admit that gravity cream contains large numbers of bacteria, but state that separator cream contains few. "Roughly 60 per cent of the organisms will be found in the bowl sediment (separator slime), 25 per cent in the separated milk, and 15 per cent in the separated cream." They also quote Eckles and Barnes as having estimated the numbers of bacteria as follows: 47 per cent in the slime, 29 per cent in the separated milk, and 24 per cent in the separated cream. Careful experiments were reported by Severin.[3] He found that the number of bacteria in the milk after separation and subsequent mixing was always larger than in the original milk, in spite of the fact that the dirt was removed. He made experiments to show that contamination from the air or some other source was not responsible for the increase. As an explanation he offered the theory that since bacteria in milk occur in clumps, or chains, or in imperfectly separated pairs, these aggregates are broken up by the force of the centrifuge and a larger number of colonies results. Russell[4] explained the occurrence of larger numbers of bacteria in centrifugal cream by the supposition that the bacteria are carried mechanically by the cream to the center of the separator.

We made a series of experiments to test the number of colonies obtainable on glucose agar from the milk as it enters the separator and then from the cream and the skim milk after leaving the separator. The contents of two large cans of milk were separated daily, the process occupying about 20 minutes. We took samples from each part at intervals of five minutes. This work was continued for

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[1] *Koch's Jahresber.*, 1897, 8, p. 151.

[2] *Bacteriology of Milk*, New York, 1903, p. 144.

[3] *Centralbl. f. Bakt.*, Abt. II, 1905, 14, p. 605.

[4] *Outlines of Dairy Bacteriology*, 1894, p. 134.

16 successive days. The results are given in Table 1 in detail and the averages in Table 2. The original milk as appears from Table 2 averaged 738 bacteria per c.c. for the total of 48 samples examined. The separator milk for the same number of tests and taken as the milk flowed from the separator contained 2,130 bacteria per c.c., and the separator cream, which tested about 40 per cent fat, had the small number of 132 bacteria per c.c. Taking the sum of the numbers found in the separator milk and separator cream as a basis of calculations we found 17 per cent of the bacteria in the cream. As it is difficult to estimate the number in the separator slime, such an estimation would not add to the accuracy of this figure, but would reduce the percentage of bacteria in cream materially. In

TABLE 1.

THE NUMBER OF COLONIES IN MILK BEFORE AND AFTER PASSING THROUGH THE SEPARATOR.

DAY	MILK BEFORE SEPARATING			SEPARATOR MILK			SEPARATOR CREAM			CALCULATED NUMBER OF BACTERIA AFTER SEPARATING AND MIXING		
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3
1	4,110	820	1,050	12,930	25,530	5,910	190	70	170	12,060	23,800	5,520
2	8,800	250	760	14,100	1,980	1,040	580	40	280	13,050	1,830	780
3	1,460	1,770	2,440	1,280	4,420	830	170	310	680	1,200	4,110	820
4	380	490	410	510	610	460	190	310	260	400	590	440
5	370	810	140	11,000	850	970	80	70	30	10,140	590	900
6	330	610	230	640	280	2,090	90	80	90	600	270	1,950
7	220	80	90	870	80	130	230	170	120	820	90	130
8	910	490	960	2,110	360	130	120	120	130	1,990	350	130
9	990	380	730	2,190	330	270	80	110	80	2,040	310	260
10	170	470	310	2,240	1,790	190	150	150	40	2,080	1,670	180
11	1,750	950	790	1,510	1,020	1,770	180	170	120	1,420	960	1,660
12	60	110	170	430	160	230	80	160	30	410	160	210
13	50	30	140	80	170	260	30	80	100	80	160	250
14	130	30	20	50	130	20	20	10	60	50	120	20
15	50	30	20	140	30	30	20	30	30	130	30	30
16	70	60	50	50	30	30	10	20	20	50	30	30
Total	19,750	7,380	8,310	50,130	37,770	14,360	2,220	1,900	2,240	46,610	35,270	13,510
Average	1,234	461	519	3,133	2,361	898	139	119	140	2,913	2,204	844

TABLE 2.

TOTALS AND AVERAGES OF 48 SAMPLES OF MILK BEFORE AND AFTER PASSING THROUGH THE SEPARATOR.

	Milk before Separating	Separator Milk	Separator Cream	Mixt Milk
Sample 1	19,750	50,130	2,220	46,610
Sample 2	7,380	37,770	1,900	35,270
Sample 3	8,310	14,360	2,240	13,510
Total	35,440	102,260	6,360	95,390
Average	738	2,130	132	1,987

the last column of the tables the numbers of bacteria are calculated according to the numbers found in the cream and skim milk, as they would appear if the cream and skim milk were mixt again after separation.

Since the conditions under which the separation took place were above reproach as far as cleanliness and handling were concerned, we are forced to the same conclusion as Severin, namely, that the larger number of colonies appearing after separation are due to bacteria originally contained in the milk. Our results seem, therefore, to bear out the theory that clumps and aggregates of bacteria which are in the milk are broken up by the violence of the process of centrifugalizing, thus increasing not the actual number of bacteria, but the number of colonies appearing on the plates. The exceedingly small number of bacteria in the centrifugal cream we can account for only on the assumption that the majority of bacteria are thrown into the milk and slime. It is a well-known fact that the aggregates of fat globules are largely broken up by the force of the separator, in consequence of which fact milk obtained by the mixing of centrifugal milk and cream shows a poor cream line, the cream rising more slowly than in milk which has not been separated. On account of this breaking up of the clumps of fat globules we believe that on the whole bacteria are not carried to the center of the centrifuge but go to the outside into the skim milk and the slime.

In gravity cream it is generally accepted that bacteria are carried to the top with the cream. In this case, the fat globules not having been broken up, the theory is more acceptable. Still, the larger number of bacteria in gravity cream can be plausibly explained on Russell's assumption that gravity cream is necessarily older than separator cream.

As stated before, the cream contained about 40 per cent fat. It is the custom of many dairies, in order to separate a rich cream, to test the exact percentage of fat, and then dilute it with skim milk until the desired amount of fat has been established. In certified milk, which is largely used for infant feeding, the usual amount of fat is 16 and 32 per cent. To judge from our experiments this mixing of separator milk and cream results in a cream having a larger number of bacteria than the original milk, since we found that the separator milk contained many more bacteria per c.c. than the whole milk. The question then confronts us, whether the number of bacteria would not be smaller if, instead of separating a cream with a high percentage of fat, the cream was separated directly with the desired amount of fat, so as to obviate the necessity of diluting it with separator milk. Experiments to determine this point are now in progress. A cream with smaller numbers of bacteria would undoubtedly be obtained, if after separation whole milk was used for dilution instead of skim milk. Obviously this cannot be done at the time the milk is modified, since whole milk contains about as much fat as it is practicable to have in modified milk and cannot serve as a diluent.

COMPARATIVE TESTS OF THE VALUE OF NARROW TOP PAILS WITH OR WITHOUT STRAINERS.

The milking pail which was used for these experiments has an opening of about six inches diameter. Into this opening is fitted a cylindrical piece with a brass sieve at the lower end. The sieve has 100 meshes to the inch. By lifting out this cylinder the milk can be poured into a larger can without the necessity of a spout on the side such as the Gurler pail has. This style of pail is easily cleaned and sterilized.

Theoretically it might be argued that the presence of a strainer or sieve might increase the number of bacteria, since some dirt, which would gather on the strainer, would be broken up by the force of the streams from the teats. Stocking[1] came to the conclusion that in most cases the strainer affords a distinct advantage and that the relative advantage gained depends upon the sanitary condition of the stable. It seems reasonable, therefore, to conclude, that the more perfect the precautions applied, the less will be the difference in bacterial counts obtained from milking into a pail with or without a strainer.

We carried out a series of 108 tests, each with and without the strainer, under the following conditions: Twelve cows were selected and a sample taken in the manner described above from the total yield of one milking of each cow. The strainer was used on alternate days so that the result represents the number of colonies per c.c.

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[1] *Storrs Agric. Exp. Sta. Bull.*, 48, 1907.

obtained from one morning's milking with the strainer and the next day without the strainer. We realize that the bacterial content of milk from the same cow may vary from day to day, but we consider the results as representing the actual conditions fairly because of the large number of tests. Table 3 shows the figures in detail and Table 4 gives a summary and the averages. The experiments were begun early in September and continued throughout the month. At first the weather was rather warm but soon turned cool, and in accordance with this change we find a more or less gradual falling off in the number of colonies. The variation in numbers of colonies in milk from the same cow from day to day is considerable; still there seems to be a certain amount of consistency, the milk from some cows having a lower bacterial content than that from others.

TABLE 3.

COMPARATIVE NUMBERS OF COLONIES PER C.C. OF MILK RECEIVED IN SMALL TOP PAILS WITH AND WITHOUT STRAINERS.

No. of Sample	No. of Cow 2		No. of Cow 3		No. of Cow 5		No. of Cow 9		No. of Cow 13		No. of Cow 15	
	Str.	Open	Str.	Open	Str.	Open	Str.	Open	Str.	Open	Str.	Open
1	390	190	240	820	280	770	580	670	310	170	560	140
2	2,320	110	80	1,300	240	6,310	470	2,160	240	380	110	2,860
3	6,540	290	2,960	20	170	30	940	70	40	40	9,600	540
4	10	20	40	80	40	40	120	960	60	70	80	90
5	20	150	80	20	130	90	210	220	370	10	160	510
6	190	2,100	90	1,210	1,690	360	2,070	1,140	470	90	90	310
7	190	70	170	40	150	40	140	70	150	570	180	70
8	20	10	10	110	30	10	70	20	210	90	10	10
9	80	20	40	20	30	90	160	40	70	50	40	350
Total	9,760	2,960	3,710	3,620	2,760	7,740	4,760	5,350	1,920	1,470	10,830	4,880
Average	1,084	320	412	402	307	860	529	594	213	163	1,203	542

No. of Sample	No. of Cow 18		No. of Cow 21		No. of Cow 22		No. of Cow 27		No. of Cow 29		No. of Cow 38	
	Str.	Open	Str.	Open	Str.	Open	Str.	Open	Str.	Open	Str.	Open
1	230	420	310	390	1,770	660	690	410	2,650	7,500	1,420	310
2	990	510	650	210	1,940	2,400	810	2,100	5,730	1,800	1,350	3,200
3	20	20	260	520	920	590	50	130	690	510	130	110
4	140	120	120	1,990	330	510	120	40	1,420	2,050	70	160
5	390	490	410	70	440	1,300	170	190	2,390	670	570	520
6	90	2,110	130	210	1,440	1,290	480	3,010	570	8,690	1,190	470
7	110	80	140	110	490	230	70	20	170	20	170	60
8	60	70	10	20	40	30	120	40	10	40	40	30
9	30	40	440	30	110	60	20	30	30	160	20	80
Total	2,060	3,860	2,470	3,550	7,480	7,070	2,530	5,970	13,660	21,440	4,960	4,940
Average	229	429	274	394	831	786	281	663	1,518	2,382	562	549

From Table 4 we see that the average of colonies obtained from the milk in open pails is 674 per c.c., while the average of the milk obtained through a sieve is 620. There is, therefore, a slight advantage in favor of the use of the sieve, altho the difference is small and possibly ranges within experimental error. We have come to the conclusion for reasons which will appear later that it is advisable to retain the strainer in the milking-pail, especially in dairies where conditions are not ideal. If the animals are not kept as scrupulously clean as they are kept in the dairy where these experiments were carried on, it is hardly possible to avoid having small particles of dirt, hairs, etc., fall into the milk and the strainer will keep these out. If there is truth in the supposition that particles of dirt may be broken up by the force of the stream from the teats during milking, this may perhaps be avoided by having a conical sieve instead of a level one, so that the dirt particles are washed down to the edge of the sieve where the force of the milk streams has been largely broken.

TABLE 4.

TOTALS AND AVERAGES OF BACTERIA IN MILK FROM PAILS WITH AND WITHOUT STRAINERS.

	Pails with Strainer	Pails without Strainer
	9,760	2,960
	3,710	3,620
	2,760	7,740
	4,760	5,350
	1,920	1,470
	10,830	4,880
	2,060	3,860
	2,470	3,550
	7,480	7,070
	2,530	5,970
	13,660	21,440
	4,960	4,940
Total	66,900	72,850
Average	5.575	6,071
Average per cow	620	674

A STUDY OF THE ACTION OF ABSORBENT COTTON STRAINER ON THE BACTERIAL CONTENT OF MILK.

In many dairies the milk from the individual cows is collected in large cans and then carried to a room for straining through cotton before reaching the bottling-room. At the Edgewood Farms a reservoir of the following construction is used for this purpose:

The strainer frame, set on a large cylindrical tank, is 14 inches high and 13 inches in diameter. In the bottom of this strainer frame there is a brass strainer of 100 meshes to the inch. This prevents loose parts of the cotton from being carried into the strained milk. Above this brass strainer there are three separate wire nets of two wires to the inch and upon each of these nets rests a layer of sterile absorbent cotton. Above the cotton there is a steel plate with 97 holes, each opening being $\frac{3}{16}$ of an inch. This steel plate is designed to break the force of the stream of milk before reaching the cotton. The strained milk reaches the cooler from the reservoir by means of a pipe, which is taken apart after each milking for sterilization.

We made tests to find whether the number of bacteria was reduced or increased in milk by straining in the manner described above. Samples were taken at intervals of 25 minutes, first from the milk in the can, then from the top of the strainer, and finally from the milk when flowing on the cooling apparatus. Thus we obtained five samples at each stage of the process, altogether 15 samples daily, and this scheme was continued for 16 days. The technic of sampling and plating was the same as in the former series of experiments. The results are tabulated in Tables 5 and 6.

The milk before straining contained an average of 2,060 bacteria per c.c. On top of the strainer the number had increased to 3,912, and after passing through the cotton the number was 2,790. There is then first a decided increase on the strainer. Possibly this increase is due to the violent breaking up of clumps of bacteria as a result of pouring a large amount of milk on top of the strainer. This theory receives support from the fact that as the time advanced the numbers increased materially, so that the sample taken 25 minutes after the first one contained more bacteria than the first sample, and 25 minutes later the number was still larger, until after the last sample was taken, that is to say, after milk has been poured on the strainer for about two hours, the number reached the highest point.

The strained milk contained less bacteria than the milk on top of the strainer, but more than the milk in the can before straining. It is, then quite evident that the straining through cotton removes some of the bacteria, but this reduction does not compensate for the numbers resulting from the breaking up of clumps, etc., on top of the strainer. The result would, therefore, be more favorable if this straining process was omitted.

Since it is practically impossible to prevent hairs, dirt, and other foreign material, covered more or less with bacteria, from occasionally gaining access to milk, it seems advisable that at some period or

TABLE 5.

NUMBER OF COLONIES IN 1 C.C. OF MILK BEFORE AND AFTER STRAINING THROUGH COTTON.

DAY	MILK IN CAN BEFORE STRAINING					MILK ON TOP OF STRAINER					MILK AFTER STRAINING				
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
1	2,790	510	2,830	660	1,840	1,389	460	1,210	1,820	1,170	2,650	1,050	1,770	610	1,790
2	630	340	2,510	9,100	610	570	620	2,400	31,000	27,000	150	6,100	1,900	14,800	2,230
3	2,050	1,750	23,220	3,840	730	1,550	1,420	51,400	1,340	21,100	1,070	780	3,010	15,900	29,900
4	12,100	4,100	1,220	30,720	1,320	5,500	2,520	2,150	1,990	970	3,160	4,610	2,500	6,250	910
5	2,280	240	2,660	290	15,000	2,120	21,000	4,900	3,880	3,220	1,670	450	1,380	240	270
6	350	80	810	140	420	260	60	930	70	260	280	130	660	260	130
7	350	60	110	1,680	490	150	130	120	890	9,320	350	3,720	290	810	24,610
8	430	110	1,550	230	1,140	260	80	2,880	330	22,050	470	110	1,930	2,100	460
9	260	90	1,140	1,080	1,050	580	370	1,490	150	2,190	110	5,490	3,330	2,820	990
10	570	950	4,740	510	2,400	410	1,050	3,500	8,460	2,300	390	3,100	5,990	1,210	1,430
11	4,080	6,920	370	590	510	3,600	14,000	2,640	5,990	2,210	6,800	3,860	8,600	4,900	1,750
12	4,140	370	270	280	380	3,180	220	270	260	340	3,500	1,200	7,800	2,340	1,220
13	290	110	90	190	530	210	90	310	26,440	210	170	2,280	1,610	4,750	270
14	190	160	210	140	70	160	40	80	140	410	390	580	460	380	260
15	60	60	110	90	70	190	60	210	80	100	220	70	2,460	120	490
16	50	30	60	290	50	40	20	110	290	110	60	30	10	250	70
Total	30,620	15,880	41,900	49,830	26,610	20,160	42,140	74,600	83,130	92,960	21,440	33,560	43,700	57,740	66,780
Average	1,914	992	2,619	3,114	1,663	1,260	2,634	4,662	5,196	5,810	1,340	2,077	2,731	3,609	4,174

other the milk should be strained. The strainer on the milking-pail answers this purpose, and it seems advantageous to retain this strainer but to omit the second straining through cotton.

In this series of experiments we also find a great variation of numbers of bacteria in milk, as the table shows. The numbers decrease with the decline of temperature. Occasionally abnormally large numbers of bacteria were found. This is probably due, among other circumstances, to changes in the force of milkers, and possibly also to the fact that some cows average higher in bacteria than others.

Several tests were made from the liquid squeezed out from the cotton strainer after all milk had passed through. The counts show that this liquid teems with bacteria, varying from 50,000 to 100,000 per c.c. This fact tends to confirm our conclusion in reference to the effect of cotton strainers.

TABLE 6.

TOTALS AND AVERAGES OF BACTERIA IN MILK BEFORE STRAINING THROUGH COTTON, ON TOP OF STRAINER, AND AFTER STRAINING

Milk before Straining	Milk on Top of Strainer	Milk after Straining
1,914	1,260	1,340
992	2,634	2,097
2,619	4,662	2,731
3,114	5,196	3,609
1,663	5,810	4,174
Total.......10,302	19,562	13,951
Average.... 2,060	3,912	2,790

AN ATTEMPT AT CLASSIFICATION OF BODY CELLS IN THE SLIME OF THE SEPARATOR.[1]

A limited study of the relative number and character of the white corpuscles and the bacteria present in separator slime was carried on in connection with the bacteriological work. For this purpose thin films of the slime were prepared daily for 16 consecutive days and half the number of these films fixt with alcohol, the other half with heat. Other films fixt by heat (made by passing the slide through the flame) were stained immediately with Löffler's methylene blue and examined. The remaining preparations were properly dated and taken to the laboratory at Chicago for a more careful examination. The films fixt with alcohol were stained with Giemsa's stain; the films fixt by heat were stained with methylene blue, and in several instances with hematoxylin and eosin, and some also with Weigert's fibrin stain.

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[1] This part has been worked out and written by A. B. Luckhardt.

In general the preparations revealed numerous polymorphonuclear leukocytes, occasionally containing many cocci or short chains of streptococci. Bacilli were rarely met with. In addition to the polymorphonuclear leukocytes there were seen small lymphocytes, appreciable numbers of large mononuclear leukocytes, as well as large cells of irregular outline with greatly vacuolated protoplasm and very pale nucleus. These latter cells were often phagocytic in nature, which fact lends support to the belief that they represent desquamated epithelial cells. As many as 20 cocci, usually diplococci, were observed in a single one of these cells. Fibrin threads were frequently present and were positively identified by means of Weigert's fibrin stain. On three consecutive days and after six days out of the 16 days, on which smears were made, the preparations stained with Giemsa's stain revealed a great number of typical eosinophiles. The protoplasm of these cells was usually filled to so large an extent with the sharply circumscribed eosinophilic granules that the nucleus was hidden from view. The cells varied in size, some being quite large and others small. Some were spherical, some ovoid. The nucleus was sometimes single, usually multilobed or distinctly polynuclear. On one of the slides the granules in the cell were plainly visible in the methylene blue stain. In this case, however, the granules had a brassy tint and not a distinct red coloration as observed in the differential Giemsa preparations.

The paucity of bacteria in all preparations surprised us and suggested the possibility that the dried plasma and the slimy sediment protected the bacteria from the action of the stain. The great number of bacteria in the separator slime of milk from a neighboring dairy and the ease of their detection convinced us that the difference in bacterial numbers per field of the microscope between the two preparations represented to some extent the difference in cleanliness in the production of milk in the two dairies.

In an exhaustive critical review of the literature on "The Relative Importance of Streptococci and Leukocytes in Milk" Harris[1] has pointed out that the "unfortunate choice of the term 'pus cell' instead of leukocyte is to be regretted." According to the classification proposed by Ehrlich and adopted by most hematologists today the white corpuscles occurring in blood belong to one of two classes, the lymphocytes and the leukocytes. The leukocytes are furthermore subdivided according to their morphology into mononuclear leukocytes, polynuclear leukocytes with neutrophile granules, or with eosinophile granules (eosinophiles), and mast cells. When speaking of pus it is most generally understood that there occur, aside from cell detritus, bacteria, fibrin, large numbers of polymorphonuclear leukocytes containing neutrophile granules. The latter are the pus cells par excellence. As far as we are aware, no investigator of the white corpuscles in milk has attempted to differentiate between them. There are no definite statements in the literature whether or not the so-called "pus cells" or leukocytes of other authors are the polymorphonuclear leukocytes of the pathologist. Our rather limited investigation, which is being completed, shows that milk of unquestionably healthy cows contains large mononuclears, small lymphocytes, and in some instances eosinophiles in appreciable numbers, altho these are not so numerous as polymorphonuclear leukocytes of the neutrophile type. In general the appearance of eosinophiles in the tissues and blood of animals, aside from cases of myelogenous leukemia, is an indication of infection of parasitic etiology, i. e., trichinosis in man, scleromiasis in horses, uncinariasis in man.

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[1] *Jour. Infect. Dis.*, 1907, Supplement No. 3, p. 50.

The importance or significance of eosinophiles in milk in particular is as obscure as the significance of the presence of white corpuscles in milk in general. Doane[1] writes: "There seems to be but one conclusion, which is that, either in the elaboration of the milk in the udder, or through the intimate association of the blood vessels in the glands, leukocytes escape into the milk." This is in accordance with the statement of Ellenberger and Günther[2] that the appearance of numerous leukocytes in the secreting alveoli of the mammary gland at the beginning (colostrum milk) and toward the end of lactation, signal the beginning and the end of lactation, and that under normal physiological conditions the number of leukocytes found in the alveoli decreases until final disappearance during active lactation. Russell and Hoffmann[1] "noted frequently a high cell content in the earlier as well as in the later stages of the period of lactation." Ellenberger and Günther furthermore state that, even in the active gland, not all the alveoli are in a state of activity, but that some alveoli and groups of alveoli, which are in a resting stage, contain numerous leukocytes in the connective tissue of the stroma of the gland and sometimes between the cells of the alveoli themselves, so that their subsequent extrusion into the alveoli and appearance in the milk are made very probable. These observations partly account for the wide variation in count of the white corpuscles in different healthy cows as noted by Bergey,[2] Doane,[3] Savage,[4] and Russell and Hoffmann.[5]

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[1] *Bull. No. 102, Maryland Agric. Exp. Sta.*, 1905.

[2] *Grundriss der vergleichenden Histologie der Haussäugethiere*, 1908, pp. 205, 206.

Harris suggested that "apart from any signs of inflammation, chemiotactic substances may play a part in leukocytosis, due to the residence of saprophytic streptococci within the udder." If, aside from these possible factors, the appearance of white corpuscles is due to the intimate association of the blood vessels with the glands, as Doane suggested, this anatomical arrangement would likewise explain the appearance of the great number of eosinophiles which are occasionally met with, for about 13.15 per cent of the white corpuscles of normal cow's blood consists of eosinophiles (Dimock and Thompson, quoted by Burnett[6]).

It appears to us that the morphology of the various white corpuscles of cow's milk and blood under normal and pathological conditions ought to receive careful investigation, just as has the morphology of the white corpuscles of the blood of healthy and diseased animals. Such a study will no doubt lead to a more satisfactory classification of the white corpuscles found in milk and will place subsequent investigations in this field on a proper scientific basis and forever render inexcusable the loose use of the term "pus cells," which suggests suppurative processes, and the general term leukocyte as including all white corpuscles present in milk.[7]

[1] *Report Wis. Agri. Exp. Sta.*, 1907, p. 231.

[2] *Bull. No. 125, Dept. of Agri., Commonwlth. of Pennsylv.*, 1904.

[3] *Bull. No. 102, Maryland Agri. Exp. Sta.*, 1905.

[4] *Jour. of Hyg.*, 1906, 6, p. 123.

[5] *Loc. cit.*

[6] *Clinical Pathology of the Blood of Animals*, 1908, p. 43.

[1] Since this paper has gone to the printer, there has come to hand a paper by Hewlett, Villar, and Rives in the *Jour. of Hyg.*, 1909, 9, p. 271, "On the Nature of the Cellular Elements Present in Milk."

SUMMARY AND CONCLUSIONS.

1. Separator cream contains a smaller number of bacteria per c.c. than the whole milk from which it is obtained. Separator milk contains more bacteria than the whole milk from which it is obtained.

2. The bacterial count in milk obtained by mixing the cream and skim milk from the separator is higher than that of the original milk.

3. Straining milk, during the process of milking, through a brass sieve removes some of the bacteria, and also removes coarse particles of dirt, which otherwise would increase the number of bacteria.

4. Straining milk through absorbent cotton before bottling results in a higher bacterial count for the strained milk.

5. Polymorphonuclear leukocytes of the neutrophile type, large mononuclear leukocytes, and small lymphocytes appear normally in the separator slime of the milk of healthy cows, and as far as we can see they bear no relation to the number of microorganisms present, inclusive of streptococci.

6. Eosinophiles may occur in the slime of the separator. The cause and significance of their presence remain problematical.

7. The white corpuscles in milk of normal and diseased cows and in the blood of the same animals should be studied, differentiated, and classified. Such a study will put the subject of leukocytes in milk on a more exact scientific basis than heretofore, and further our knowledge of the significance of the relative number of the various corpuscles in milk in normal and diseased conditions of the cow in general, and in pathological processes of the mammary glands and the udder in particular.

The authors believe that the cellular elements constantly found in milk and described as polymorphonuclear leukocytes are to be looked upon as "detached young epithelial cells" which arise from the germinal layer and have been stimulated to great multiplication by the invasion of streptococci into the lumina of the alveoli. The authors also report the histological appearance of the mammary glands as described by Pfaundler in various stages of glandular activity. We quote part of the description of one of the stages: "The cells appear indefinite, their outline and limiting surfaces indistinct. There is a marked infiltration of the alveoli with leukocytes (many eosinophiles), which are found in such great numbers in the interstitial tissue and the epithelial layer and lumina of the alveoli, that the remaining structure is only recognized with difficulty." We were unaware of this fact when the article was written. The great infiltration of the glandular tissue by the eosinophiles and their subsequent extrusion into the alveoli probably explain our detection of them in the separator slime. We are of the opinion that the majority of the cellular elements found in the separator slime are white blood corpuscles, particularly polymorphonuclear leukocytes. On the other hand, we are ready to admit that some of the elements are distinctly desquamated epithelial elements. The authors also record the practical absence of phagocytosis. Our observations on this point, altho not extensive, revealed many examples of phagocytosis, both by the pholymorphonuclear leukocytes and by desquamated epithelial cells.

DAIRY SCORE CARDS.

P. G. HEINEMANN.

Dairy score cards for the guidance of inspectors are gaining in favor rapidly. Several plans have been proposed, the principle of which is the enumeration of the conditions to be considered and criticized. By rating these conditions with a certain number of points according to merit, the relative degree of perfection is determined. The sum of the points for perfect scores varies in different cards from 100 to 500. The score card which is probably the most popular has been designed in the Dairy Division of the Department of Agriculture in Washington. This card allows 40 points for a perfect score in equipment, and 60 points for methods, a total of 100 points for a perfect dairy. It is desirable to have uniform methods of inspection throughout the country, so as to give comparable results, and the figure 100 for a perfect score is perhaps the most practical. If the number is much higher it is rather difficult to distribute the points proportionately to the relative importance of the various items; on the other hand, if the number is too low, it is difficult to go into detail to a degree necessary for proper guidance of the inspector. During the writer's experience in scoring dairies the card designed by the Department of Agriculture has been used, and altho excellent results have been obtained, it seemed profitable to extend some of the items and give more detail. This is important in view of the fact that the development of dairy conditions is progressing rapidly and new points are constantly coming up which must be represented on the score card. The card as it now stands is not quite specific enough in some instances and consequently leaves too much to the judgment of inspectors who are sometimes inexperienced and perhaps prejudiced. One of the chief benefits of the score card system of inspection is that suggestions are given to inspectors who are not accustomed to this kind of work, and even in the hands of experts the card is a good reminder, not only of points which may otherwise be overlooked, but particularly of points which previously have been found to be amiss. In a modified score card the writer has made an attempt to overcome the shortcomings pointed out, and in order to carry out this idea it was found necessary to increase the total number of points to 200. The final score is then divided by two

DAIRY SCORE CARD.

EQUIPMENT.

		Score	
		Perfect	Allowed
COWS			
Health		8	....
Apparently in good health	1		
Tuberculin tested once a year, reacting animals found and removed	1		
Tuberculin tested twice a year, reacting animals found and removed	3		
Tuberculin tested once a year, no reacting animals found	5		
Tuberculin tested twice a year, no reacting animals found	7		
Comfort		6	....
Temperature of stable	1		
Bedding renewed daily	1		
Kind of bedding	4		
Hay	1		
Clean straw	2		
Wood shavings	4		
STABLES			
Location		3	....
Construction		14	....
Loft	3		
Holes in ceiling tightly shut	1		
No holes, food brought in from without	2		
Loft not used or absent	3		
Floor	3		
Tight wood	1		
Cement	2		
Cement covered with wood in stalls	3		
Gutter	2		
Tight wood	1		
Cement	2		
Walls tight	1		
Ceiling tight	1		
Stalls	2		
Clean wood partitions	1		
Iron pipe partitions	2		
Stanchions	2		
Movable wood stanchions	1		
Swinging iron pipe stanchions	2		
Drainage		2	....
Light		5	....
Distribution	1		
Amount	4		
3 square feet per cow	1		
3½ square feet per cow	3		
4 square feet per cow	4		
Ventilation		4	....
Cubic space per cow		4	....
Less than 300 cubic feet	0		
300-400 cubic feet	1		
400-500 cubic feet	2		
500-600 cubic feet	3		
600-800 cubic feet	4		
800-1,000 cubic feet	3		
Above 1,000 cubic feet	0		
Washstands in stable		1	....
Stable for sick cows		3	....
Construction	1		
Condition	1		
Removed 100 feet or more from other stables	1		
MILK ROOM			
Location		2	....
Convenient	1		
Clean surroundings	1		
Construction		3	....
Walls and ceiling tight	1		
Walls cemented	2		
Walls enameled	3		
Light		2	....
Abundant	1		
Distribution	1		
Ventilation		1	....
Doors and windows screened		1	....
Floor		2	
Cement	1		
Tile or other smooth material	2		
Reservoir for milk outside of milk room		2	....
If protected	2		
Not protected	1		
MILKING-SUITS			
White suits and caps		1	....
Care of suits		2	....
One clean suit daily	1		
Two clean suits daily	2		
UTENSILS			
Small top milk pail		3	....
Cans seamless		1	....
Bottles capped by machine		1	....
Caps sterilized		1	....
Facilities for washing and sterilizing bottles		2	....
MILK COOLER			
Covered		1	....
Cooling		3	....
Cooled with well water	1		
Cooled with ice water	2		
Cooled with brine	3		
FOOD			
Food clean and wholesome		2	....
Total		80	....
METHODS			
COWS			
General condition		5	....
Special conditions		5	....
Udders clipped	2		
Soiled hair on body kept clipped	1		
Legs curried and kept clean	1		
Tails washed and kept clean	1		
STABLES			
Cleanliness		16	....
Floors	4		
Cleanliness	2		
Free from hay, etc	2		

Score for Equipment.....+Score for Methods......=......Divided by 2......=......Final Score.

DAIRY SCORE CARD.

METHODS.

		Score Perfect	Score Allowed
Walls clean and free from cobwebs	2		
Ceiling clean and free from cobwebs	2		
Ledges clean	2		
Mangers clean	2		
Partitions and iron pipe clean	2		
Gutters clean	2		
Windows and doors		4	....
Cleanliness	2		
Screened	2		
Ventilation		2	....
Stable air		6	....
Good in general	3		
Sweet at milking time	3		
Removal of manure from stable		4	....
Daily by shovel	1		
Daily by wagon	2		
Daily by wheelbarrow	3		
Daily by suspended carrier	4		
BARNYARD			
General condition		4	....
Drainage	2		
Cleanliness	2		
Removal of manure from barnyard		3	....
To pit 50 feet distant	1		
To pit 100 feet distant	2		
To pit more than 100 feet distant	3		
FOOD			
Perfect score for food		4	....
Handling of food	2		
Silage fed after milking only	1		
No food shortly before milking	1		
BOTTLING-ROOM			
Cleanliness		2	....
Hot water for cleaning	1		
Live steam for cleaning	2		
Room steamed before bottling		1	....
Condition of windows		2	....
Cleanliness	1		
Screened	1		
Milk covered during passage to cooler		4	....
UTENSILS			
Washing of bottles		2	....
In boiling water	1		
In live steam	2		
Handling of bottles		2	....
Kept inverted	1		
Kept inverted and placed in bottling room hot	2		

		Score Perfect	Score Allowed
Cans and pails		8	....
Cleanliness	5		
Washed, not scalded	1		
Washed and scalded	3		
Washed and steamed	4		
Washed and steamed under pressure	5		
Inverted in pure air	3		
MILKING			
Clean dry hands		3	....
Hands washed for each cow		1	....
Milk weighed in separate room		2	....
Udders washed before milking		3	....
First streams of milk removed		2	....
Spilled on floor	1		
Collected in separate vessel	2		
Cleanliness of milkers		2	....
Milking stools		2	....
Clean wood	1		
Clean iron	2		
Milk pail		2	....
Strainer clean	1		
Strainer sterilized	2		
HANDLING OF MILK			
Cleanliness of attendants		2	....
Milk promptly removed from stable		2	....
Cooling of milk		8	....
Below 60° F	1		
Below 55° F	2		
Below 50° F	4		
Below 45° F	6		
Below 40° F	8		
Time elapsing between milking and cooling		5	....
30 minutes	1		
25 minutes	2		
20 minutes	3		
15 minutes	4		
10 minutes	5		
Storage		8	....
Below 60° F	1		
Below 55° F	2		
Below 50° F	4		
Below 45° F	6		
Below 40° F	8		
Transportation		4	....
Dry blankets or covered wagon	1		
Jacket or wet blanket	2		
In boxes filled with chipped ice	4		
Total for Methods		120	....

Score for Equipment......+Score for Methods .....=......Divided by 2......=......Final Score.

(*Reverse of card*)

DAIRY SCORE CARD.

Owner or lessee of farm...
P. O. address...................................State...........................
Total number of cows.......................Number milking....................
Date of inspection..., 190....
REMARKS..
....
....
....
(*Signed*)...
Inspector

and by this method the score is again on the basis of 100, thus making the results comparable to the results obtained with the Department card. The general plan of the Department card has been retained and taken as a basis for making extensions and additions. Producers of milk are gradually being educated to understand the principles involved in sanitary milk production and are introducing improvements in their dairies in many ways. In justice to the most progressive ones the score card should be designed to record these improvements in some manner, which object can be obtained only by stating details.

It is hardly profitable to discuss the various points where changes and additions have been made. It may be stated, in a general way, that an effort has been made in designing this score card to give sufficient detail for the guidance of the inspector and to remind him of the conditions to be scrutinized and criticized without omitting any necessary parts. This card has been of great assistance in recalling certain points which at previous inspections had to be criticized. It is an advantage also of this card that it is never necessary to use fractions of a point. The card permits more delicate grading than previous cards, without giving occasion for favoring one dairy more than another. Slight, but more or less important, differences in equipment and methods employed are recorded with accuracy and this fact may act as a stimulant to the dairies concerned to make improvements more rapidly.

A score card which states details without being overburdened may also have the advantage of enabling boards of health, milk commissions, large dairy concerns, etc., to classify the dairies according to their equipment and management and thus control the output. The score of a dairy producing certified milk, for instance, might range from 95 to 100, of a dairy producing inspected milk 85 to 95, etc. The exact range must be decided upon by the supervising body. The progressive improvements are naturally shown to better advantage in proportion to the sensitiveness of the score card, and inasmuch as the plan of the card, here presented, is substantially the same as the plan of the Department of Agriculture card, and inasmuch as the same numerical relation is obtained by dividing the result by two, the figures remain comparable whether obtained by one card or the other.